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CONTENTS

PREFACE

SUSTAINABILITY — MORE THAN A BUZZ-WORD?

The eleven chapters in Volume 26 on the topic of environmental sustainability exemplify the broadened purview of the *Annual Review of Ecology and Systematics*, which now explicitly includes "applied" systematics and ecology, such as conservation biology and fisheries (see Preface to Volume 25 of *ARES*). What could be more applicable to us all than the sustainability of those resources on which human life on earth depends? The members of the Editorial Committee of *ARES* hope these chapters will promote linkages among disciplines that have contributions to make to the deliberations about our collective future.

Several chapters were written by authors invited to discuss sustainability from the perspectives of disciplines not typically included in *ARES*. In assembling this section, I have encountered one of the major problems faced by those attempting to integrate various sources of information bearing on this issue of ultimate gravity—communication. As becomes obvious from reading the chapters, the very term "sustainability" has a wide variety of applications and connotations. Topics and authors for the section were selected in part to demonstrate some of the ways in which this word is employed—a diversity that extends to the underlying assumptions and principles used in discussions of and proposals for sustainability. This section will have achieved one of its aims if readers come away recognizing some of these differences and the need to be explicit in their own usage and about the underpinnings of their positions.

This section illustrates disciplinary differences in style as well as in usage and opinion. The difficulty of recognizing, and then getting beyond, such differences may contribute to a lack of communication between disciplines (e.g. 8). A piece of writing in a style too different from that of a reader's discipline may be viewed as inaccessible or may not be taken seriously, because it does not conform to the customary formula for "real science." For example, natural scientists charge some social science with lacking rigor, but our emphasis on rigor has recently been questioned (5, 18). Authors who accepted the invitation (and challenge!) to write for this section are presumably among those most convinced of the necessity for cross-disciplinary communication to effect the changes needed to sustain human life on earth. Yet, editorial intervention was required to craft the contributions from fields

outside the typical focus of *ARES* into a format at once representative of those disciplines—and so in their construction expressing the cross-disciplinary message of this section—and sufficiently familiar to be acceptable to *ARES* readers.

Biologists must understand the style as well as the information of the social sciences to participate fully in the debate about, and development of, a rational, scientifically based environmental policy. Extending even beyond the expanded horizons of *ARES* is essential for subjects that have policy implications because political, sociological, and economic concerns often override purely scientific considerations (e.g. 1, 21). One perspective on the recent collapse of the northwest Atlantic cod fishery is that economic interests and regulatory bureaucracy were unable or unwilling to respond to advice from scientists (10). As this introduction is being written in mid-1995, the US Congress is proposing to reduce the weight it gives in its deliberations to data from the natural sciences and to increase that given to social sciences (such as economics and politics). [How ironic, then, that this same Congress is proposing to eliminate support for research in the social sciences by the US National Science Foundation (11).] These chapters are intended to serve as bridges, in both style and substance, to a literature that deals with sustainability from perspectives that may be different from those to which we biological scientists are accustomed.

Among the principles addressed in this collection are some as seemingly incontrovertible as the value of biodiversity. Much of conservation is based on what most ecologists accept as a biological reality—the inherent value of diversity (see, for example, the chapter by Hartshorn). Nelson proposes that, regardless of scientific rationale, its prominence stems from underlying human religious or cultural values. Science is not unique in this regard; all human activities, he argues, including economics, are value-laden. From their perspective outside the discipline of economics, biologists may readily recognize certain premises of economics as more beliefs than objectively verifiable realities, but it may come as a surprise that outsiders to ecology can view biodiversity in similar light (for more on values, see, for example, 5).

Rather than purely an article of faith, biodiversity may be among those tenets classified by Hardin (8) as "default principles of science," which cannot be proven but are consistent with knowledge. The importance of biodiversity to ecology is related to the biological premises of evolutionary and functional uniqueness. The experience of environmental science is that the interaction of each piece of the biosphere with others contributes in some incompletely understood but unique fashion to produce the whole, so removal of any component of the system may have unforeseeable consequences for other components and the entire system. But as species become extinct at an ever-increasing rate (e.g. 13), it is unrealistic—and perhaps counter-

productive—to insist that all be saved. The chapter by Humphries, Vane-Wright & Williams provides some guidance in the process of selecting taxa to conserve. It is likely that if biologists do not participate in this triage, it will be done by people with priorities other than the ecological, or there will be no selection at all.

The value that environmental scientists regard as inhering in habitats, organisms, and their variety is one of the more obvious contrasts with that of conventional economics, in which a resource acquires value only when put to direct human use. In this perspective trees not grown in a plantation or oceanic fish stocks acquire value only when harvested, their value as inventory, or "natural capital" having been ignored. Only recently have some people in economics, such as Goodland (7, p. 1), recognized that, from the perspective of the environment, "consumption of natural capital is liquidation." As discussed by Hartshorn, the participation of scientists in decision-making can provide the biological basis for rational linkage of conservation with development. Biologists can also address values of biological resources other than through direct consumption (e.g. 4, 15). Setting these values and having them recognized in the marketplace are problematic, according to Daly, but in late 1995, the World Bank announced it had made a first atttempt (16).

Hardin (8, p. 56) regards attitudes toward limits as one of the three "major ways in which ecology and economics differ." Although some economists no longer believe literally that natural resources are inexhaustible (17), operationally the conviction persists in the premise of "substitutability." As alluded to by Clark and explained more fully by Daly, this basic assumption of economics posits that one resource can substitute for another. For example, implements once made of metal (e.g. kitchen strainers) or wood (e.g. baskets for refuse) are now made of plastic because of the economic calculus that includes raw material availability, costs of fabrication and distribution, durability, and consumer preference. Substitutability is irreconcilable with biological uniqueness. Hoffman & Carroll point out that even options provided by "modern" technologies for crops are rather severely constrained because of limitations on flexibility imposed by the unique evolutionary history of each genome.

Substitutability is necessary to another core principle of conventional economics, as discussed by Nelson, Daly, and Clark—that of continual growth (e.g. 9). But it is antithetical to most biological systems, which exhibit dynamic equilibria. [It might be argued that the growth espoused by most economists is like organic diversity, which appears to have increased since the end of the Precambrian (2). However, enhanced taxonomic richness does not necessarily imply increased biomass, and so it might more properly be analogized to development, a concept that, according to Daly, should denote increased qual-

ity of human life, clearly distinct from quantitative growth.] Even the most benign agricultural practices, Buol emphasizes, remove nutrients until ultimately one is operationally exhausted, preventing further growth. The limiting nutrient can be replaced—at some financial cost and only by removal from another source—but there is no substitute for it.

Regulation, a major issue in sustainability, is especially problematic for common pool resources (e.g. 6). Regulation of oceanic fisheries, as discussed by Hilborn, Walters, & Ludwig, has had mixed success; not surprisingly to biologists, the success seems to correlate with the biology of the organisms. Nichols, Johnson & Williams trace the history of waterfowl management in the United States, which, through trial and error, appears to have resulted in a scientifically based, societally acceptable policy for management. Lessons for other common pool biological resources may be limited, for in the United States, waterfowl are exploited largely for sport, so harvest can be modified as necessary without threat to human livelihood. Some problems in exploitation of common pool resources and some case studies in distribution of water are examined by Becker & Ostrum, who conclude that various systems may be equally viable. However, the most successful models they discuss appear to be for subsistence-level or small-market agriculture and small populations.

Vandermeer assesses, in light of growing human populations, the ecological and economic potentials of various regimes proposed as alternatives to conventional agriculture. Such consideration of scale effects is rare in debates about sustainability, according to Hardin (8). Buol points out that distribution, and not merely size, of human populations affects the rate at which nutrients are depleted from the soil. As people are increasingly concentrated away from the source of their food, nutrients are exported in that food from rural soil to urban sewers and then to their ultimate repositories, distant from their sources. Similarly, commercial pelagic fisheries being established in the tropical Pacific remove the nutrients from a nutrient-limited ecosystem to distant areas. This differs from both traditional fisheries in the tropics where the nutrients are recycled within the local ecosystem, and the large-scale high latitude fisheries in which the resource is more widespread and nutrient limitation is less. Thus, ecologically, a fishery and a crop may be more similar than two fisheries, a distinction economists may not recognize. If such considerations are to be factored into policy, they must be put forth by ecologists, according to Clark and other authors in this volume as well as to those writing elsewhere (e.g. 3, 5, 19).

Another consequence of the increased urbanization that has accompanied human population growth is an obscuring of human reliance on natural resources (e.g. 8, 20). It is distressingly easy to find examples of ignorance of this linkage. *The Straits Times* newspaper of Singapore recently reprinted an article (14) on environmental pollution by an economist who asserted: "In the past, much of the economic growth and industrialisation in all Asean [Association of Southeast Asian Nations] states, except Singapore, depended upon the exploitation of natural resources, including forests, coastal zones, fertile agricultural lands and water resources." Few readers of *ARES* would contend that Singapore is independent of natural resources because its economy is based on industry and services rather than agriculture and extractive activities. Yet, apparently, some economists believe that to be true, and may even propose policy on that basis.

We hope this collection of chapters will reinforce the realization that not everyone shares information, definitions, and perspectives, even when ostensibly pursuing similar goals and using identical words. Beyond recognizing the diversity, we hope this special section will help readers of *ARES* to cross disciplinary boundaries by providing new perspectives, new information, and new literature. The disciplines represented by the readers of *ARES* are central to the concerns about how to achieve sustainability, for, without a firm grounding in ecological reality, "sustainability" is in danger of "becom[ing] a cant phrase, a 'greenwash' that will fade away like so many previous rhetorical colorings" (12, p. 1).

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